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Evaluation of non-linear parameter on spin torque oscillator

◦Sumito Tsunegi, Hitoshi Kubota, Kay Yakushiji, Akio Fukushima, and Shinji Yuasa (AIST)

E-mail: tsunegi.sb@aist.go.jp

Spin torque oscillator (STO) is a device which transforms the spin dynamics to the radio frequency (rf) signal through magneto-resistance effect. This rf signal however has intense non-linearity which originates from the non-linearity of spin dynamics. The non-linearity results in broadening the linewidth due to the coupling between amplitude noise δ_a and phase noise δ_ϕ.[1,2] The amplitude of the non-linearity is defined by the non-linear parameter ν, and the linewidth is defined as $2(1+\nu^2)\Delta f_0$ by using linear linewidth Δf_0. ν and Δf_0 are evaluated from the analysis of noise power spectrum density and equation (1) shown below.[1,2] In this work, we discuss the mechanism how to further reduce the linewidth by applying this analysis to our vortex-STO having high emission power and narrow linewidth.[3]

We prepared a circular shaped STO having the structure of sub/buffer/PtMn(15)/CoFe(2.5)/Ru(0.98)/ CoFeB(3.0)/MgO(1.0)/FeB(3.0)/MgO(1.0)/Ta/Ru with 450 nm ϕ. The rf signal was generated from STO by applying dc current I_{dc} and perpendicular field H_{perp}=2.3 kOe.

Figs. 1 (a) and (b) show I_{dc} dependence of Δf_0 and ν, respectively. The Δf_0 and ν decreases when I_{dc} increases and these values are quite small compared with the previous results[2] of Δf_0=35 kHz and ν=2.5. Fig.1(c) shows the linewidth obtained from the FFT of time-domain measurement (black closed circle) and calculated values of $2(1+\nu^2)\Delta f_0$ (blue blank circle). The linewidth of FFT rather follows the behavior of ν than that of Δf_0, indicating that the narrow linewidth of our vortex-STO seems to originate from the small ν.

$$\delta_a(f) = \frac{\Delta f_0}{\pi} \frac{1}{f_p^2 + f^2} \quad (1-1)$$

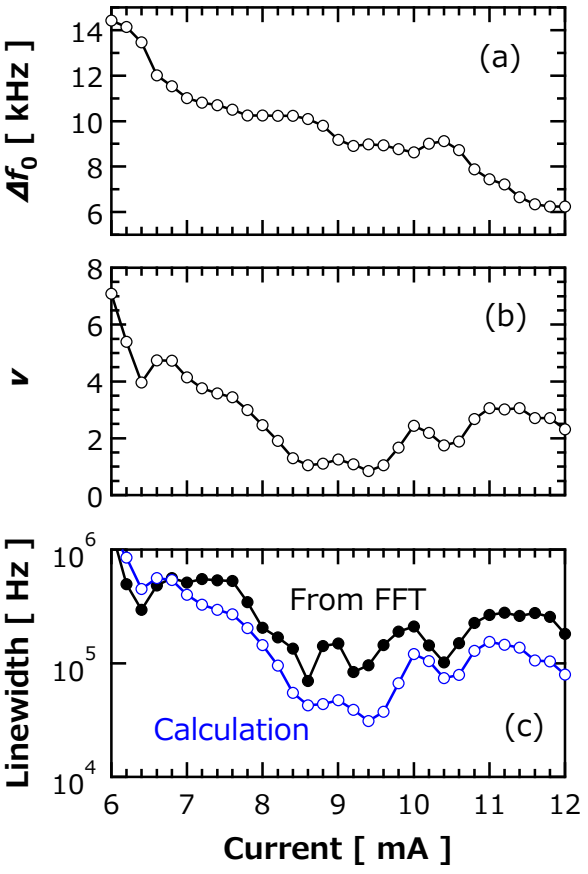
$$\delta_\phi = \frac{\Delta f_0}{\pi f^2} + \nu^2 \frac{2f_p^2}{f^2} \delta_a(f) \quad (1-2)$$

<Reference>

1) M. Quinsat, et al. Appl. Phys. Lett. 97, 182507 (2010)

2) E. Grimaldi, et al. Rhys. Rev. B 89, 054435 (2014)

3) S. Tsunegi, et al. APEX 7, 063009 (2014)



Figs. 1 Current dependence of (a) Δf_0 and (a) ν, and (c) linewidth.